

EUROPEAN CENTRAL BANK
WORKING PAPER SERIES



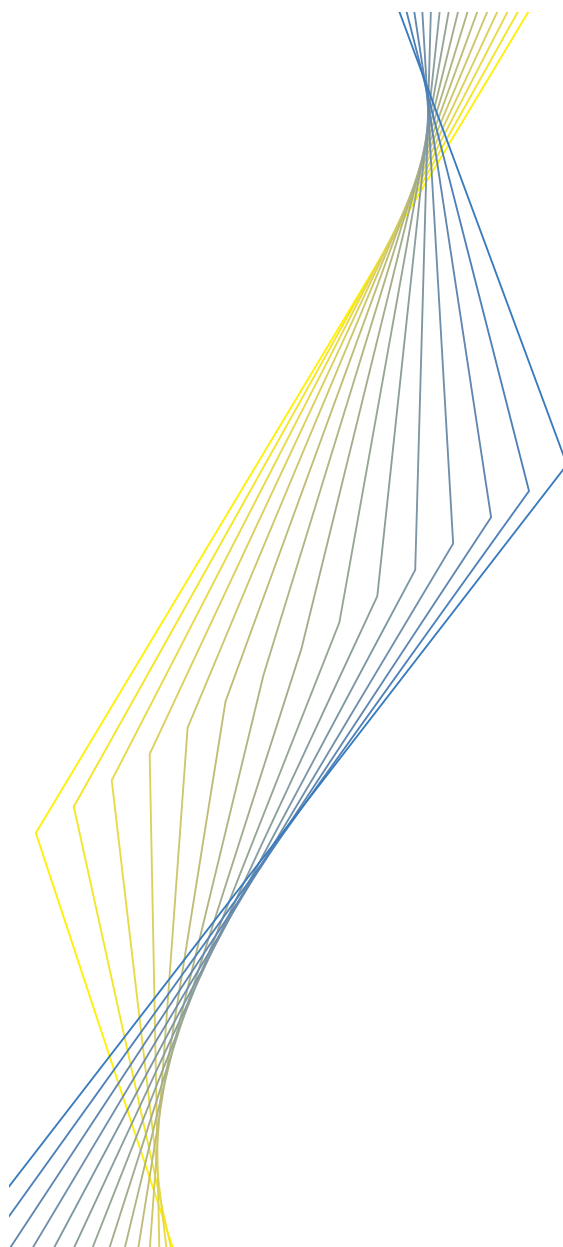
WORKING PAPER NO. 259

**IMPLICIT TAX CO-ORDINATION
UNDER REPEATED
POLICY INTERACTIONS**

**BY MARCO CATENARO AND
JEAN-PIERRE VIDAL**

September 2003

EUROPEAN CENTRAL BANK
WORKING PAPER SERIES



WORKING PAPER NO. 259

**IMPLICIT TAX CO-ORDINATION
UNDER REPEATED
POLICY INTERACTIONS¹**

**BY MARCO CATENARO² AND
JEAN-PIERRE VIDAL³**

September 2003

¹ The authors are grateful to Bertrand Crettez, Luca Onorante, Pierre Pestieau, Ludger Schuknecht, Rolf Strauch, Emmanuel Taugourdeau, Juergen von Hagen, as well as an anonymous referee of the ECB Working Paper Series for comments and constructive criticism. An earlier version of this paper was presented at the 5th Banca d'Italia Workshop on Public Finance (Perugia, 3-5 April 2003). Comments from Vieri Ceriani, David Heald, Michael Keen, Ranjana Madhusudhan and other workshop participants are also gratefully acknowledged. The opinions expressed herein are those of the author(s) and do not necessarily reflect those of the European Central Bank. This paper can be downloaded without charge from <http://www.ecb.int> or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=457527.

² Marco Catenaro: European Central Bank, email: marco.catenaro@ecb.int.

³ Jean-Pierre Vidal: European Central Bank, email: jean-pierre.vidal@ecb.int.

© **European Central Bank, 2003**

Address	Kaiserstrasse 29 D-60311 Frankfurt am Main Germany
Postal address	Postfach 16 03 19 D-60066 Frankfurt am Main Germany
Telephone	+49 69 1344 0
Internet	http://www.ecb.int
Fax	+49 69 1344 6000
Telex	411 144 ecb d

All rights reserved.

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

The views expressed in this paper do not necessarily reflect those of the European Central Bank.

ISSN 1561-0810 (print)

ISSN 1725-2806 (online)

Contents

Abstract	4
Non-technical summary	5
1 Introduction	6
2 The “one-shot” tax game	8
Proposition 1	12
3 Game under repeated interactions	12
Proposition 2	15
Proposition 3	15
4 Conclusion	16
References	17
European Central Bank working paper series	18

Abstract

In the context of a stylised game theoretical framework of capital tax competition, we show that when repeated policy interactions are associated to a systematic punishment of the deviating policymaker, a co-ordinated outcome can be the solution to the non co-operative tax game. This result suggests that explicit forms of policy co-ordination, such as a centralised tax authority, could in fact be largely unnecessary.

JEL Classification: E61, H87

Keywords: Policy Co-ordination, International Fiscal Issues

Non-technical summary

It is often argued that, when capital is able to move freely, governments' ability to rely on capital taxation becomes increasingly constrained. As a result, fiscal authorities would be made better off by more actively co-ordinating their tax policies or, alternatively, by relinquishing their tax authority in favour of a supra-national authority. While the common wisdom that capital mobility exerts a "race-to-the-bottom" on capital tax rates is widely accepted in the theoretical literature on tax competition, the empirical literature, however, has found little support for this outcome.

This paper attempts to reconcile theory and evidence by extending the basic tax competition model to account for repeated policy interactions between fiscal authorities. It is argued that, when such interactions are associated to a systematic "punishment" of the deviating policymaker, the Nash equilibrium outcome of static tax competition models may not necessarily coincide with the outcome of the tax game in the context of a repeated interaction framework. On the contrary, governments may secure the "co-operative" outcome by threatening to retaliate if one of them deviates from the co-ordinated tax rates. In such a case, "explicit" policy co-ordination – for instance via a supra-national tax authority – would not be necessary, since "implicit" co-ordination mechanisms would in fact be at work.

However, one could argue that some form of co-ordination may be desirable to avoid the pitfalls associated to competition from smaller economies, when there are strong incentives to free ride. Large regions face a weaker response of the capital stock to tax rates, which means that they are less inclined to engage in tax competition. By contrast, as competition generally benefits smaller economies, the latter are more likely to be the source of negative externalities to large countries in the absence of supra-national regulation.

1. Introduction

It is often argued that, in an environment in which capital is able to move freely, governments' ability to rely on capital taxation becomes increasingly constrained. Fiscal authorities would then be made better off by more actively co-ordinating their tax policies or, alternatively, by relinquishing their tax authority in favour of a supra-national authority. While the common wisdom that capital mobility exerts a "race-to-the-bottom" on capital tax rates is widely accepted in the theoretical literature on tax competition, the empirical literature so far has found little support for this outcome.

The theoretical literature on tax competition⁴ is largely based on conventional static frameworks, in which the tax game lasts only one period, thereby disregarding the possibility of repeated interactions between policymakers. Concerning capital income taxation, in particular, it traditionally relies on the assumption that capital owners are sensitive to net returns to capital (i.e. to tax differentials) when making portfolio choices or investment decisions. Settings of these tax competition models are essentially twofold. On the one hand, small open economies compete for a fixed amount of internationally mobile capital (e.g. Zodrow and Mieszkowski, 1986), but fail to internalise the impact of their respective tax policies on the world after-tax return to capital. On the other hand, governments are assumed to engage in tax games *à la* Nash, in the context of which they are, however, aware that their tax policy affects the after-tax return to capital (see for instance Wildasin, 1988). Under both settings, capital mobility drives down capital tax rates, albeit to a lower extent in the latter class of models. When tax revenues finance public goods, this results in an under-provision of local public goods that negatively affects the citizens' welfare. Nevertheless, tax competition is welcome if governments are revenue-maximisers and subordinate their competitive behaviour to, for example, the aim of increasing their size. Clearly, a normative assessment of tax competition ultimately depends on the views one has on the preferences of governments (Edwards and Keen, 1996).

Even though the above static tax competition models generally conclude that tax competition leads to a "race-to-the-bottom", empirical research has so far found limited support for a significant downward effect of capital mobility on tax rates. In this regard, a recent review of empirical studies on the sensitivity of capital flows to tax rates by Krogstrup (2003) has also confirmed that there is no strong empirical evidence supporting the conclusions of tax competition models. Regarding the location choice of foreign direct investment, it is stressed that, on the one hand, empirical evidence supports the view that the tax policy of a country does not affect the choice of its resident investors between home and foreign investment. On the other hand, a country's tax policy affects the investment decisions of prospective foreign investors.

⁴ See Wilson (1999) for a comprehensive survey.

This paper attempts to reconcile theory and evidence by extending the basic tax competition model to account for repeated policy interactions between governments. We argue that, when such interactions are associated to a systematic “punishment” of the deviating policymaker, the Nash equilibrium outcome of static tax competition models may not necessarily coincide with the outcome of the tax game in a repeated interaction framework. On the contrary, governments may secure a co-operative outcome by threatening to retaliate if one of them deviates from the co-ordinated tax rates. In such a case, explicit policy co-ordination via a supra-national tax authority would not be necessary. However, one could argue that some explicit tax co-ordination might be desirable in order to avoid the pitfalls of competition from smaller economies, when there are incentives to free ride. This policy asymmetry relates to the fact that large regions face a weaker response of the capital stock to tax rates, which means that they are less inclined to engage in tax competition. By contrast, as competition generally benefits smaller economies, the latter are more likely to be the source of negative externalities to large countries in the absence of supra-national regulation.

To our best knowledge, there are only few papers in the literature addressing the topic of fiscal competition in a repeated interaction framework. In his model of property tax competition, Coates (1993) assumes that governments do not take into account the externalities associated to the use of their domestic tax rate, showing that there may be incentives to subsidise capital. Cardarelli, Taugourdeau and Vidal (2002) extend upon the framework developed by Coates, setting up a repeated interactions model of tax competition and establishing the conditions under which tax policy harmonisation can result from repeated interactions between the policymakers. They show that tax harmonisation will not prevail in the case of strong regional asymmetries⁵, in which case the establishment of a centralised fiscal authority is suggested as a solution to the tax competition problem. In a related game theoretical approach inspired by Barro and Gordon (1983), Fourçans and Warin (2002) also find that the lack of explicit tax harmonisation may not lead to a “race-to-the-bottom” of tax rates, as a co-operative outcome can result from repeated interactions between governments.

This paper aims to build upon the model by Cardarelli *et al.* by looking at capital tax competition in a repeated interaction framework characterised by the absence of capital mobility sunk costs. While such costs were postulated in their paper to avoid a zero tax rate on capital under the assumption of linear technologies, the underlying assumption in our paper is that production occurs according to Cobb-Douglas technologies. Furthermore, we analyse the role of cross-country asymmetries on the outcome of the tax competition repeated game. We adopt the view that governments compete for a fixed world supply of capital and abstract from welfare considerations, assuming that governments only aim to maximise tax revenues. Moreover, governments are either short-sighted, maximising only current revenue, or far-sighted, seeking to maximise a discounted sum of current

⁵ Taugourdeau (2002) extends the analysis of Cardarelli *et al.* (2002) by considering a bargaining equilibrium between governments.

and future tax revenues. Only under the second scenario is the co-ordinated tax outcome ultimately sustainable, provided cross-country asymmetries remain limited and governments are sufficiently patient.

The paper proceeds as follows. Section 2 develops a streamlined one-shot model of tax competition. Section 3 extends this model to account for repeated interactions, while section 4 concludes.

2. The "one-shot" tax game

Let us consider a world economy consisting of two countries (indexed with subscripts i and j), whose governments compete to tax the income of a fixed and exogenously given world supply of capital. The allocation of capital between country i and j satisfies:

$$2k = k_i + k_j \quad (1)$$

where $2k$ stands for the world total supply of capital. Labour is perfectly immobile and in fixed supply, whereas capital is perfectly mobile. The gross marginal return to capital invested in country i is given by:

$$r_i = \alpha A_i k_i^{\alpha-1} \quad (2)$$

where A_i is a country-specific parameter, capturing cross-country differences in their endowments of immobile factors such as, for example, labour, land, or even differences in total factor productivity. For the sake of simplicity, in the remainder of this paper we shall refer to A_i as the size of country i . The underlying production technologies are assumed to be of the Cobb-Douglas type. Governments levy taxes on capital according to the source principle of taxation⁶. The capital tax revenue in country i is:

$$T_i = t_i \alpha A_i k_i^\alpha \quad (3)$$

where t_i is country i 's capital income tax rate. Perfect capital mobility implies that net marginal returns to capital are equal in all locations. The equilibrium capital allocation is therefore determined by the arbitrage condition:

⁶ There are two polar principles of international taxation: the residence (of the taxpayer) principle and the source (of income) principle. Under the residence principle, residents are taxed on their whole income regardless of its origin. Under the source principle, all incomes originating in a country are taxed in this country regardless of the country of residence of the taxpayer. The source principle is usually assumed in models of tax competition; see Razin and Sadka (1994) for a survey on tax competition.

$$(1-t_i)\alpha A_i k_i^{\alpha-1} = (1-t_j)\alpha A_j k_j^{\alpha-1} \quad (4)$$

Governments act strategically with a view to maximising capital income tax revenue. In order to address the question of whether tax co-ordination is feasible in the absence of any co-ordinating supranational authority, we assume that governments are intrinsically revenue-maximisers, hence departing from the view of governments as benevolent social planners. In this context, it should be noted that our model abstracts not only from labour income taxation but also from spending, so that we are focusing on a precise aspect of tax policy, namely the taxation of internationally mobile capital.

Governments choose their capital income tax rate under the constraint that capital is perfectly mobile, taking other governments' tax policies as given. This is a Nash tax game, where government i maximises its capital income tax revenue (3) from an internationally mobile tax base under the arbitrage condition for capital (4), taking government j 's capital tax rate as given. Government i 's reaction function is therefore the solution to the following maximisation problem:

$$\max_{t_i} t_i \alpha A_i [k_i(t_i, t_j)]^\alpha \quad (5)$$

where

$$k_i(t_i, t_j) = \frac{2k \left(\frac{A_i(1-t_i)}{A_j(1-t_j)} \right)^{\frac{1}{1-\alpha}}}{1 + \left(\frac{A_i(1-t_i)}{A_j(1-t_j)} \right)^{\frac{1}{1-\alpha}}} \quad (6)$$

is the equilibrium stock of capital as a function of tax rates resulting from the arbitrage condition (4).

After some computations, the reaction function of government i , $t_i = R_i(t_j)$, is defined by the following equation, which results from the first-order condition of problem (5):

$$1-t_j = \frac{A_i}{A_j} (1-t_i)^{2-\alpha} \left(\frac{1-\alpha}{\alpha-(1-t_i)} \right)^{1-\alpha} \quad (7)$$

Note that although one does not obtain an analytical solution for government i 's reaction function R_i , the property of the above expression, which implicitly defines this function, can be easily analysed. Equation (7) is of the form:

$$y = f(x) = \Gamma x^{2-\alpha} \left(\frac{1-\alpha}{\alpha-x} \right)^{1-\alpha}$$

where x, y and Γ denote $1-t_i, 1-t_j$ and $\frac{A_i}{A_j}$, respectively. The domain of f is $[0, \alpha[$ and its range $[0, +\infty[$. One can easily check that f is strictly increasing on $]0, \alpha[$ and that $f(0) = 0$, $\lim_{x \rightarrow \alpha} f(x) = +\infty$ and $f'(0) = 0$.

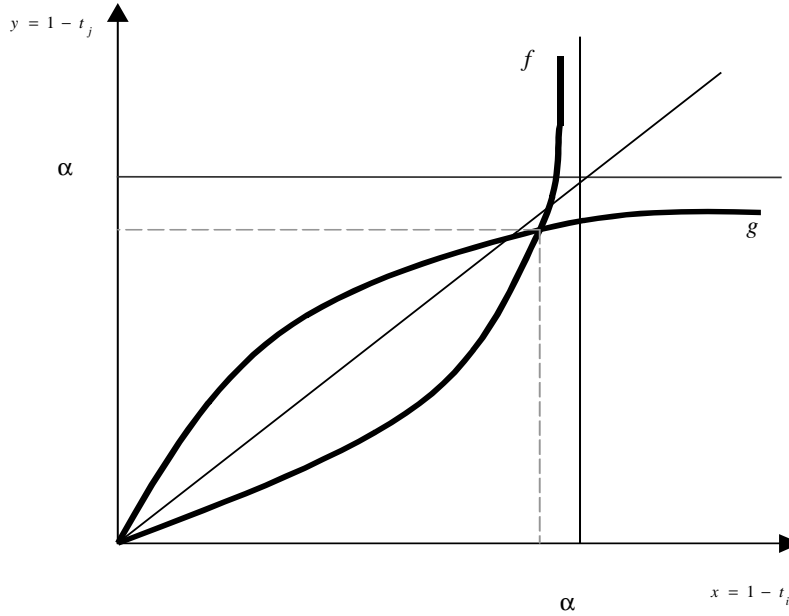
The reaction function of government j is derived analogously:

$$1-t_i = \left(\frac{A_i}{A_j} \right)^{-1} (1-t_j)^{2-\alpha} \left(\frac{1-\alpha}{\alpha-(1-t_j)} \right)^{1-\alpha} \quad (8)$$

This expression, which can be easily obtained from (7) by substituting i with j , is of the form:

$$x = h(y) = \Gamma^{-1} y^{2-\alpha} \left(\frac{1-\alpha}{\alpha-y} \right)^{1-\alpha}$$

Figure 1
Nash Reaction Functions
($A_i < A_j$)



The qualitative properties of this function are identical to those of the function f we studied above. In particular, we can define the inverse function $g = h^{-1} : [0, +\infty[\rightarrow [0, \alpha[$, which is also strictly increasing on $]0, +\infty[$. One can easily check that $\lim_{x \rightarrow 0} g'(x) = +\infty$. The intersection of the curves representing the functions f and g characterises the Nash tax rates. The qualitative properties of these functions ensure the existence and uniqueness of the Nash equilibrium of this tax game, as illustrated by figure 1. The Nash tax rates belong to the interval $]1 - \alpha, 1[$.

Multiplying (7) by (8), one obtains a simple relation between $x^N = 1 - t_i^N$ and $y^N = 1 - t_j^N$:

$$(\alpha - x^N)(\alpha - y^N) = (1 - \alpha)^2 x^N y^N \quad (9)$$

Plugging back (9) into (7) yields a new expression, the solution of which characterises the Nash tax rate of government i , $t_i^N = 1 - x^N$:

$$\Gamma^{\frac{1}{1-\alpha}} (1 - \alpha) \left(\frac{x}{\alpha - x} \right)^{\frac{2-\alpha}{1-\alpha}} (1 - (2 - \alpha)x)^{\frac{1}{1-\alpha}} = 1 \quad (10)$$

When countries are symmetric ($A_i = A_j$ or $\Gamma = 1$), the Nash tax rate is easily calculated from (10):

$$t^N = \frac{2(1 - \alpha)}{2 - \alpha} \quad (11)$$

The equilibrium allocation of capital can be also computed by plugging the Nash tax rates into equation (6):

$$k_i^N = \frac{2k\Gamma^{\frac{1}{1-\alpha}} \left(\frac{x^N}{y^N} \right)^{\frac{1}{1-\alpha}}}{1 + \Gamma^{\frac{1}{1-\alpha}} \left(\frac{x^N}{y^N} \right)^{\frac{1}{1-\alpha}}} \quad (12)$$

$$k_j^N = 2k - k_i^N \quad (13)$$

Finally, the Nash tax revenues are defined as:

$$T_i^N = \alpha_i^N A_i (k_i^N)^\alpha \quad (14)$$

$$T_j^N = \alpha_j^N A_j (2k - k_i^N)^\alpha \quad (15)$$

The following proposition characterises the relationship between cross-country asymmetries in size and the equilibrium tax rates.

Proposition 1

An increase in the relative size of country i implies an increase in the Nash tax rate of government i and a decrease in the Nash tax rate of government j .

Proof. We take the logarithmic derivative of equation (10):

$$\frac{1}{1-\alpha} \frac{d\Gamma}{\Gamma} + \frac{2-\alpha}{1-\alpha} \frac{dx^N}{x^N} + \frac{2-\alpha}{1-\alpha} \frac{dx^N}{\alpha - x^N} - \frac{2-\alpha}{1-\alpha} \frac{dx^N}{1-(2-\alpha)x^N} = 0$$

$\frac{dx}{d\Gamma}$ is of the same sign as:

$$-\frac{1}{x^N} - \frac{1}{\alpha - x^N} + \frac{1}{1-(2-\alpha)x^N} = -\frac{(x^N)^2 - \alpha(3-\alpha)x^N + \alpha}{x^N(\alpha - x^N)(1-(2-\alpha)x^N)}$$

Let us study the sign of the polynomial:

$$P(x) = x^2 - \alpha(3-\alpha)x + \alpha$$

Since we have $P'(0) = -\alpha(3-\alpha) < 0$, $P'(\alpha) = \alpha(\alpha-1) < 0$ and $P(\alpha) = \alpha(\alpha-1)^2 > 0$, we conclude that $P(x) > 0$ for all $x \in [0, \alpha]$.

Hence: $\frac{dx}{d\Gamma} < 0$.

From equation (9) it also follows that $\frac{dy^N}{dx^N} > 0$ ■

This proposition states that, in a two-country model, the tax rate differential is exacerbated by asymmetries in country sizes. Intuitively, this is explained by the fact that large countries face a weaker response of their capital stock to tax rates, allowing them to maintain higher tax rates than small countries.

3. Game under repeated interactions

In this section we examine how repeated interactions between governments can affect their behaviour regarding taxation of internationally

mobile capital. Extending this simple tax competition model to a dynamic environment, we assume that governments maximise the discounted sum of their tax revenues. The objective of government i can therefore be written as:

$$V_i = \sum_{t=0}^{+\infty} \delta_i^t T_{i,t} \quad (16)$$

where $T_{i,t}$ stands for government i 's capital income tax revenue in period t and δ_i is government i 's discount factor. In each period t governments play a stage game similar to the one-shot tax game described in the previous section. Clearly, an infinite repetition of the Nash strategies is a solution to the repeated tax game, which gives governments the following payoffs:

$$V_i = \sum_{t=0}^{+\infty} \delta_i^t T_i^N \quad (17)$$

$$V_j = \sum_{t=0}^{+\infty} \delta_j^t T_j^N \quad (18)$$

However, governments can achieve higher levels of capital income tax revenues by setting capital income tax rates in a co-operative manner. For instance, they could meet and decide on co-ordinated tax rates, not necessarily equal across countries but still higher than the Nash tax rates. Let us denote with $t_i^c (> t_i^N)$ and $t_j^c (> t_j^N)$ the pair of co-ordinated tax rates. More specifically, we consider the possibility for governments to co-ordinate on a common capital income tax rate ($t_i^c = t_j^c = t^c < 1$).

In a framework of repeated interactions between governments, tax co-ordination can be underpinned by trigger-type strategies. Each government co-operates and levies the co-ordinated tax rate as long as the other government co-operates and reverts to the Nash tax rate otherwise. In the repeated tax game, the tax strategy of government j can be expressed as follows:

$$t_{j,t+1} = \begin{cases} t^c & \text{if } t_{i,t} = t^c \\ t_j^N & \text{otherwise} \end{cases}$$

If governments implement their tax policies in a co-ordinated manner, the government s ($=i,j$) can achieve the following payoffs:

$$V_s^C = \sum_{t=0}^{+\infty} \delta_s^t T_s^C = \sum_{t=0}^{+\infty} \delta_s^t \alpha_s^c A_s (k_s^C)^\alpha \quad (19)$$

where the international allocation of capital is:

$$k_i^C = \frac{2k\Gamma^{\frac{1}{1-\alpha}}}{1 + \Gamma^{\frac{1}{1-\alpha}}} \quad (20)$$

$$k_j^C = \frac{2k}{1 + \Gamma^{\frac{1}{1-\alpha}}} \quad (21)$$

Tax co-ordination prevails if governments have no incentive to deviate from the co-ordinated tax rate. The deviating government reaps short-run benefits but incurs long-run losses compared to tax co-ordination.

Without loss of generality, we shall consider the incentives to deviate of government j in the remainder of this paper. If it chooses to deviate, government j sets its tax rate according to its reaction function. This government's tax rate is its best reply against government i playing t^C . Hence, t_j^D is the solution to the following equation, which implicitly defines t_j^D as a function of t^C :

$$\frac{(1-t_j^D)^{2-\alpha}}{(t_j^D - (1-\alpha))^{1-\alpha}} = \frac{\Gamma(1-t^C)}{(1-\alpha)^{1-\alpha}} \quad (22)$$

By definition of the reaction function, note that $t_j^D = t_j^N$ if $t^C = t_i^N$. One can easily check from (22) that there exists a unique $t_j^D \in]1-\alpha, t^C[$ for all $t^C \in]t_i^N, 1[$ and that the deviating tax rate varies positively with the co-ordinated tax rate ($\frac{dt_j^D}{dt^C} > 0$). It

should also be noted that, not surprisingly, international capital flies from the country that implements the co-ordinated strategy to the deviating country, increasing its short-run tax revenue ($k_j^D > k_j^C$). Government j can enjoy only once the benefits of its treachery, as government i will thereafter revert to the Nash tax strategy. However, government j 's value of the continuation game is the Nash payoff, V_j^N . The payoff the deviating government can achieve is given by:

$$V_j^D = T_j^D + \delta_j V_j^N = \alpha_j^D A_j (2k - k_i^D)^\alpha + \delta_j V_j^N \quad (23)$$

Our next proposition emphasises how tax co-ordination can emerge endogenously from repeated interactions.

Proposition 2

In the absence of cross-countries asymmetries, a co-ordinated capital income tax rate is sustainable if governments are sufficiently patient.

The proof is simple and intuitive, as the result is quite similar to the folk theorem in game theory. Tax co-ordination is sustainable if the loss incurred by the deviating country in terms of future losses stemming from the setback from the co-ordinated to the Nash tax strategies exceeds the short-run gain generated by undercutting the co-ordinated tax rate. Hence, co-ordination of tax policies is sustainable if:

$$V_j^D = T_j^D + \delta_j V_j^N < V_j^C \quad (24)$$

Multiplying (24) by $(1 - \delta_j)$ we obtain:

$$(1 - \delta_j)T_j^D + \delta_j T_j^N < T_j^C \quad (25)$$

It can be easily checked that, when δ_j tends to 1, this expression can be simplified as:

$$t_j^N < t^C \quad (26)$$

since in the symmetric case, we have $k_i^N = k$ and $k_i^C = k$.

Condition (26) holds owing to the definition of the co-ordinated tax rates. Hence, if governments' discount factors are sufficiently close to 1, tax co-ordination can be an outcome of the tax game with repeated interactions. It follows that in the case of symmetric countries, the endogenous outcome of the repeated tax game suggests that there is no intrinsic need for greater centralisation. Nevertheless, centralised tax co-ordination or harmonisation may be desirable in the presence of strong regional asymmetries, when there are incentives to free ride.

Our final proposition deals with the sustainability of decentralised or endogenous tax co-ordination in the presence of strong regional asymmetries.

Proposition 3

If cross-countries differences in size are sufficiently large, decentralised co-ordination on a common capital income tax rate is not sustainable.

In order to show that decentralised tax co-ordination cannot be the outcome of the repeated tax game, we shall proceed as follows. First, we consider the feasibility condition in the limit case where governments' discount factors tend to 1. Second,

we prove that this condition cannot hold whenever asymmetries are sufficiently large. Condition (25) can be written as follows:

$$\left(\frac{t_j^N}{t^C}\right)^{\frac{1}{\alpha}} < \frac{1}{1 + \Gamma^{\frac{1}{1-\alpha}}} \frac{1}{1 - \frac{k_i^N}{2k}} \quad (27)$$

Using expression (12) we obtain:

$$\left(\frac{t_j^N}{t^C}\right)^{\frac{1}{\alpha}} < \frac{1 + \Gamma^{\frac{1}{1-\alpha}} \left(\frac{1 - t_i^N}{1 - t_j^N}\right)^{\frac{1}{1-\alpha}}}{1 + \Gamma^{\frac{1}{1-\alpha}}} \quad (28)$$

When the indicator for regional asymmetries, Γ , tends to infinity, one can easily check from equations (9) and (10) that t_i^N and t_j^N tend to 1 and $1 - \alpha$, respectively.

When Γ tends to infinity, condition (28) becomes: $\left(\frac{1 - \alpha}{t^C}\right)^{\frac{1}{\alpha}} < 0$. Since the LHS of this expression is strictly positive, we have shown by contradiction that decentralised tax co-ordination is not sustainable if regional asymmetries are sufficiently large.

4. Conclusion

Tax harmonisation in Europe is a recurrent debate. While static theoretical models of tax competition traditionally point to the dangers of harmful tax competition, empirical evidence supporting the extreme view of a “race-to-the-bottom” of tax rates remains weak. This suggests that implicit co-ordination mechanisms may in fact be at work. In this paper, we argued that repeated interactions between policy-makers may be key to reconciling theory with evidence. Repeated interactions and the threat to revert to the unpleasant Nash equilibrium forever may lead to co-ordination of tax strategies also in the absence of a supra-national tax authority.

REFERENCES

- Barro, R. and D. Gordon (1983), "Rules, Discretion and Reputation in a Model of Monetary Policy", *Journal of Monetary Economics* 12, pp. 101-122
- Coates, D. (1993), "Property Tax Competition in a repeated game", *Regional Science and Urban Economics* 30, pp. 167-181
- Cardarelli, R., Taugourdeau, E. and J-P. Vidal (2002), "A Repeated Interaction Model of Tax Competition", *Journal of Public Economic Theory* 4, pp. 19-38
- Edwards, J. and M. Keen (1996), "Tax Competition and Leviathan", *European Economic Review* 40, pp. 113-13
- Fourçans, A. and T. Warin (2002), "Tax Harmonization in Europe: Do the Member States Give the Right Signal", *mimeo*.
- Krogstrup, S. (2003), "Are Capital Taxes Racing to the Bottom in the European Union", HEI Working Paper No. 01/2003.
- Razin, A. and E. Sadka (1994), "International fiscal policy coordination and competition", *Handbook of International Macroeconomics*, F. van der Ploeg (Ed.), Basil Blackwell
- Taugourdeau, E. (2002), "Is fiscal cooperation always sustainable when regions differ in size? Lessons for the EMU", Cahiers de la MSE no. 2002.27, University of Paris I
- Wildasin, D.E. (1988), "Nash Equilibria in Models of Fiscal Competition", *Journal of Public Economics* 35(2), pp. 229-240
- Wilson, J. (1999), "Theories of Tax Competition", *National Tax Journal* 52(2), pp. 269-304.
- Zodrow, G. R. and P. Mieszkowski (1986), "Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods", *Journal of Urban Economics* 19, pp. 356-370

European Central Bank working paper series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (<http://www.ecb.int>).

- 202 "Aggregate loans to the euro area private sector" by A. Calza, M. Manrique and J. Sousa, January 2003.
- 203 "Myopic loss aversion, disappointment aversion and the equity premium puzzle" by D. Fielding and L. Stracca, January 2003.
- 204 "Asymmetric dynamics in the correlations of global equity and bond returns" by L. Cappiello, R.F. Engle and K. Sheppard, January 2003.
- 205 "Real exchange rate in an inter-temporal n-country-model with incomplete markets" by B. Mercereau, January 2003.
- 206 "Empirical estimates of reaction functions for the euro area" by D. Gerdesmeier and B. Roffia, January 2003.
- 207 "A comprehensive model on the euro overnight rate" by F. R. Würtz, January 2003.
- 208 "Do demographic changes affect risk premiums? Evidence from international data" by A. Ang and A. Maddaloni, January 2003.
- 209 "A framework for collateral risk control determination" by D. Cossin, Z. Huang, D. Aunon-Nerin and F. González, January 2003.
- 210 "Anticipated Ramsey reforms and the uniform taxation principle: the role of international financial markets" by S. Schmitt-Grohé and M. Uribe, January 2003.
- 211 "Self-control and savings" by P. Michel and J.P. Vidal, January 2003.
- 212 "Modelling the implied probability of stock market movements" by E. Glatzer and M. Scheicher, January 2003.
- 213 "Aggregation and euro area Phillips curves" by S. Fabiani and J. Morgan, February 2003.
- 214 "On the selection of forecasting models" by A. Inoue and L. Kilian, February 2003.
- 215 "Budget institutions and fiscal performance in Central and Eastern European countries" by H. Gleich, February 2003.
- 216 "The admission of accession countries to an enlarged monetary union: a tentative assessment" by M. Ca'Zorzi and R. A. De Santis, February 2003.
- 217 "The role of product market regulations in the process of structural change" by J. Messina, March 2003.

- 218 “The zero-interest-rate bound and the role of the exchange rate for monetary policy in Japan” by G. Coenen and V. Wieland, March 2003.
- 219 “Extra-euro area manufacturing import prices and exchange rate pass-through” by B. Anderton, March 2003.
- 220 “The allocation of competencies in an international union: a positive analysis” by M. Ruta, April 2003.
- 221 “Estimating risk premia in money market rates” by A. Durré, S. Evjen and R. Pilegaard, April 2003.
- 222 “Inflation dynamics and subjective expectations in the United States” by K. Adam and M. Padula, April 2003.
- 223 “Optimal monetary policy with imperfect common knowledge” by K. Adam, April 2003.
- 224 “The rise of the yen vis-à-vis the (“synthetic”) euro: is it supported by economic fundamentals?” by C. Osbat, R. Ruffer and B. Schnatz, April 2003.
- 225 “Productivity and the (“synthetic”) euro-dollar exchange rate” by C. Osbat, F. Visselaar and B. Schnatz, April 2003.
- 226 “The central banker as a risk manager: quantifying and forecasting inflation risks” by L. Kilian and S. Manganelli, April 2003.
- 227 “Monetary policy in a low pass-through environment” by T. Monacelli, April 2003.
- 228 “Monetary policy shocks – a nonfundamental look at the data” by M. Klaeffing, May 2003.
- 229 “How does the ECB target inflation?” by P. Surico, May 2003.
- 230 “The euro area financial system: structure, integration and policy initiatives” by P. Hartmann, A. Maddaloni and S. Manganelli, May 2003.
- 231 “Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero” by G. Coenen, A. Orphanides and V. Wieland, May 2003.
- 232 “Describing the Fed’s conduct with Taylor rules: is interest rate smoothing important?” by E. Castelnuovo, May 2003.
- 233 “The natural real rate of interest in the euro area” by N. Giammarioli and N. Valla, May 2003.
- 234 “Unemployment, hysteresis and transition” by M. León-Ledesma and P. McAdam, May 2003.
- 235 “Volatility of interest rates in the euro area: evidence from high frequency data” by N. Cassola and C. Morana, June 2003.

- 236 "Swiss monetary targeting 1974-1996: the role of internal policy analysis" by G. Rich, June 2003.
- 237 "Growth expectations, capital flows and international risk sharing" by O. Castrén, M. Miller and R. Stiebert, June 2003.
- 238 "The impact of monetary union on trade prices" by R. Anderton, R. E. Baldwin and D. Taglioni, June 2003.
- 239 "Temporary shocks and unavoidable transitions to a high-unemployment regime" by W. J. Denhaan, June 2003.
- 240 "Monetary policy transmission in the euro area: any changes after EMU?" by I. Angeloni and M. Ehrmann, July 2003.
- 241 "Maintaining price stability under free-floating: a fearless way out of the corner?" by C. Detken and V. Gaspar, July 2003.
- 242 "Public sector efficiency: an international comparison" by A. Afonso, L. Schuknecht and V. Tanzi, July 2003.
- 243 "Pass-through of external shocks to euro area inflation" by E. Hahn, July 2003.
- 244 "How does the ECB allot liquidity in its weekly main refinancing operations? A look at the empirical evidence" by S. Ejerskov, C. Martin Moss and L. Stracca, July 2003.
- 245 "Money and payments: a modern perspective" by C. Holthausen and C. Monnet, July 2003.
- 246 "Public finances and long-term growth in Europe – evidence from a panel data analysis" by D. R. de Ávila Torrijos and R. Strauch, July 2003.
- 247 "Forecasting euro area inflation: does aggregating forecasts by HICP component improve forecast accuracy?" by K. Hubrich, August 2003.
- 248 "Exchange rates and fundamentals" by C. Engel and K. D. West, August 2003.
- 249 "Trade advantages and specialisation dynamics in acceding countries" by A. Zaghini, August 2003.
- 250 "Persistence, the transmission mechanism and robust monetary policy" by I. Angeloni, G. Coenen and F. Smets, August 2003.
- 251 "Consumption, habit persistence, imperfect information and the lifetime budget constraint" by A. Willman, August 2003.
- 252 "Interpolation and backdating with a large information set", by E. Angelini, J. Henry and M. Marcellino, August 2003.
- 253 "Bond market inflation expectations and longer-term trends in broad monetary growth and inflation in industrial countries, 1880-2001", by W. G. Dewald, September 2003.

- 254 “Forecasting real GDP: what role for narrow money?”, by C. Brand, H.-E. Reimers and F. Seitz, September 2003.
- 255 “Is the demand for euro area M3 stable?”, by A. Bruggeman, P. Donati and A. Warne, September 2003.
- 256 “Information acquisition and decision making in committees: a survey”, by K. Gerling, H. P. Grüner, A. Kiel and E. Schulte, September 2003.
- 257 “Macroeconomic modelling of monetary policy”, by M. Klaeffling, September 2003.
- 258 “Interest rate reaction functions and the Taylor rule in the euro area”, by P. Gerlach-Kristen, September 2003.
- 259 “Implicit tax co-ordination under repeated policy interactions”, by M. Catenaro and J.-P. Vidal, September 2003.